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PNNL-14354, Rev. 2
DRAFT

Post-Closure Groundwater Monitoring Plan for the 1324-N Surface Impoundment and 1324-NA Percolation Pond

M. J. Hartman

~~August~~ November 2004

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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~~July~~ November 2004

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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

The 1324-N Surface Impoundment (1324-N) and the 1324-NA Percolation Pond (1324-NA), located in the 100-N Area of the Hanford Site, are regulated units under the *Resource Conservation and Recovery Act* (RCRA). Surface and underground features of these units have been removed, and laboratory analyses showed that the soil met closure performance standards. The sites have been backfilled and revegetated.

The U. S. Department of Energy (DOE) asked Pacific Northwest National Laboratory (PNNL) to prepare this plan as part of the Groundwater Performance Assessment Project (groundwater project). This document will replace the previous RCRA monitoring plans (Hartman 2002 and RCRA monitoring portion of Borghese et al. 1996) for the 1324-N and 1324-NA units after it is incorporated into the Hanford Facility RCRA Permit.

This document describes RCRA post-closure monitoring for the period following surface closure until a final groundwater record of decision is issued for the 100-NR-2 Operable Unit, of which 1324-N and 1324-NA groundwater is a part. After final groundwater remedial action decisions are made for the 100-NR-2 Operable Unit, this plan may need revision to reflect those decisions.

The monitoring network comprises the following ~~near-field~~ wells~~, which will be sampled semiannually~~:

Near-Field Wells	Plume-Tracking Wells	
199-N-59	199-N-2	199-N-26
199-N-71 (upgradient)	199-N-3	199-N-34
199-N-72	199-N-16	199-N-56
199-N-73	199-N-19	199-N-57
199-N-77 (deeper well)	199-N-21	199-N-64
		199-N-67

Near-Field Wells	Plume-Tracking Wells	
199-N-59	199-N-2	199-N-26
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199-N-77 (deeper well)	199-N-21	199-N-64
		199-N-67

~~199-N-59~~
~~199-N-71 (upgradient)~~

~~199-N-72~~
~~199-N-73~~
~~199-N-77 (deeper well)~~

~~Data from additional wells that are sampled for the objectives of other RCRA units, 100-NR-2 Operable Unit, or the *Atomic Energy Act*, will be used to define the sulfate and sodium plumes. Those wells generally are sampled annually.~~

~~The wells will be sampled for the following parameters:~~ The downgradient, near-field wells are sampled semiannually and the other wells are sampled annually for the following parameters:

Constituents of Interest	**Supporting Constituents**
Sulfate	Water Level
Sodium	pH
	Specific conductance
	Temperature
	Turbidity
	Alkalinity
	Anions
	Metals (filtered)

RCRA groundwater monitoring for the 1324-N and 1324-NA units is part of the groundwater project. Project staff schedule sampling and initiate paperwork. The project uses subcontractors for sample collection, shipping, and analysis. The groundwater project's quality control program is designed to assess and enhance the reliability and validity of groundwater data. This is accomplished through evaluating the results of quality control samples, conducting audits, and validating groundwater data.

~~Sections 1.0 through 5.0 of this document are intended to be incorporated into the Hanford Facility RCRA Permit. Other portions of the document are not intended for incorporation into the Permit. References are intended to be deleted prior to incorporation in the Permit.~~

Acknowledgments

Many thanks to Christopher Thompson of the Groundwater Project, who provided the Quality Control information presented in this document. Thanks also to Stuart Luttrell for providing a peer review.

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1.0 Introduction

The 1324-N Surface Impoundment and 1324-NA Percolation Pond Treatment, Storage, and Disposal (TSD) units are *Resource Conservation and Recovery Act* (RCRA) regulated units in 100-N Area of the Hanford Site. This document describes RCRA post-closure groundwater monitoring, conducted as part of Hanford's groundwater project. This monitoring plan will be implemented upon approval of a modification to the Hanford Facility RCRA Permit that incorporates portions of this plan.

~~Sections 1.0 through 5.0 of this document are intended to be incorporated into the Hanford Facility RCRA Permit. Other portions of the document are not intended for incorporation into the Permit. References are intended to be deleted prior to incorporation in the Permit.~~

The 1324-N and 1324-NA units (Figure 1.1) were used to treat and dispose of effluent from a water demineralization plant and related units. The 1324-NA Percolation Pond (also known as the 120-N-1 waste site) was an unlined pond used to neutralize and dispose of corrosive waste from 1977 to 1986 and to dispose of pre-neutralized waste from 1986 through 1991. The adjacent 1324-N Surface Impoundment (also known as the 120-N-2 waste site) was used to neutralize waste from 1986 to 1988. It was a double-lined pond with a leachate collection system. No leaks were detected throughout its period of use.

Soil samples were collected from the site in 1992 and 1993 from the surface to as deep as 23 meters. The samples were analyzed for heavy metals, organics, cyanide, pH, and anions. Organic constituents were not detected, and concentrations of other constituents were within background ranges (DOE 2002).

As required by the closure plan, surface facilities (sampling shed, liner) and underground features (leachate collection system, delivery pipeline) have been removed. Samples were collected from soil remaining at this site. Results indicate the remedial action objectives have been met (BHI 2002). The sites have been backfilled and revegetated. A Certification of Closure by a professional engineer has been completed for these units.[a]

The units are combined into a single waste management area for groundwater monitoring because they are adjacent to one another and the same type of waste was treated or stored in both. The 1324-NA Percolation Pond has contaminated groundwater with sulfate. Post-closure groundwater monitoring is required due to this contamination.

The closure plan for the 1324-N and 1324-NA units states, "During the post-closure period, monitoring of groundwater will continue under a corrective action program in accordance with WAC 173-303-645(11). A groundwater monitoring plan will be developed for 1324-N and 1324-NA and implemented prior to incorporation of this post-closure plan into the Permit. ... Because the groundwater monitoring data continues to show exceedances of sulfate concentrations above the secondary drinking water standard (250 mg/L), corrective action to remove or treat the sulfate will be required. Corrective actions will be determined in a ROD for the 100-NR-2 OU" (Appendix B of DOE 2002).

(a) Letter from J. Hebdon, U.S. Department of Energy Richland Operations Office (DOE-RL) to M. Wilson, Washington State Department of Ecology, "Certification of Closure for the 1324-N Surface Impoundment and 1324-NA Percolation Pond," dated February 7, 2003.

The final decision for cleanup of the sulfate plume will be made as part of the 100-NR-2 groundwater operable unit, which includes groundwater beneath the entire 100-N Area. Until that decision is made, the objectives of RCRA post-closure monitoring are (a) to track trends in sulfate compared to the drinking water standard, and (b) to define the extent of the sulfate plume. Thus, no statistical evaluations are necessary.

This monitoring plan will be modified, as necessary, to reflect the final record of decision for the 100-NR-2 Operable Unit.

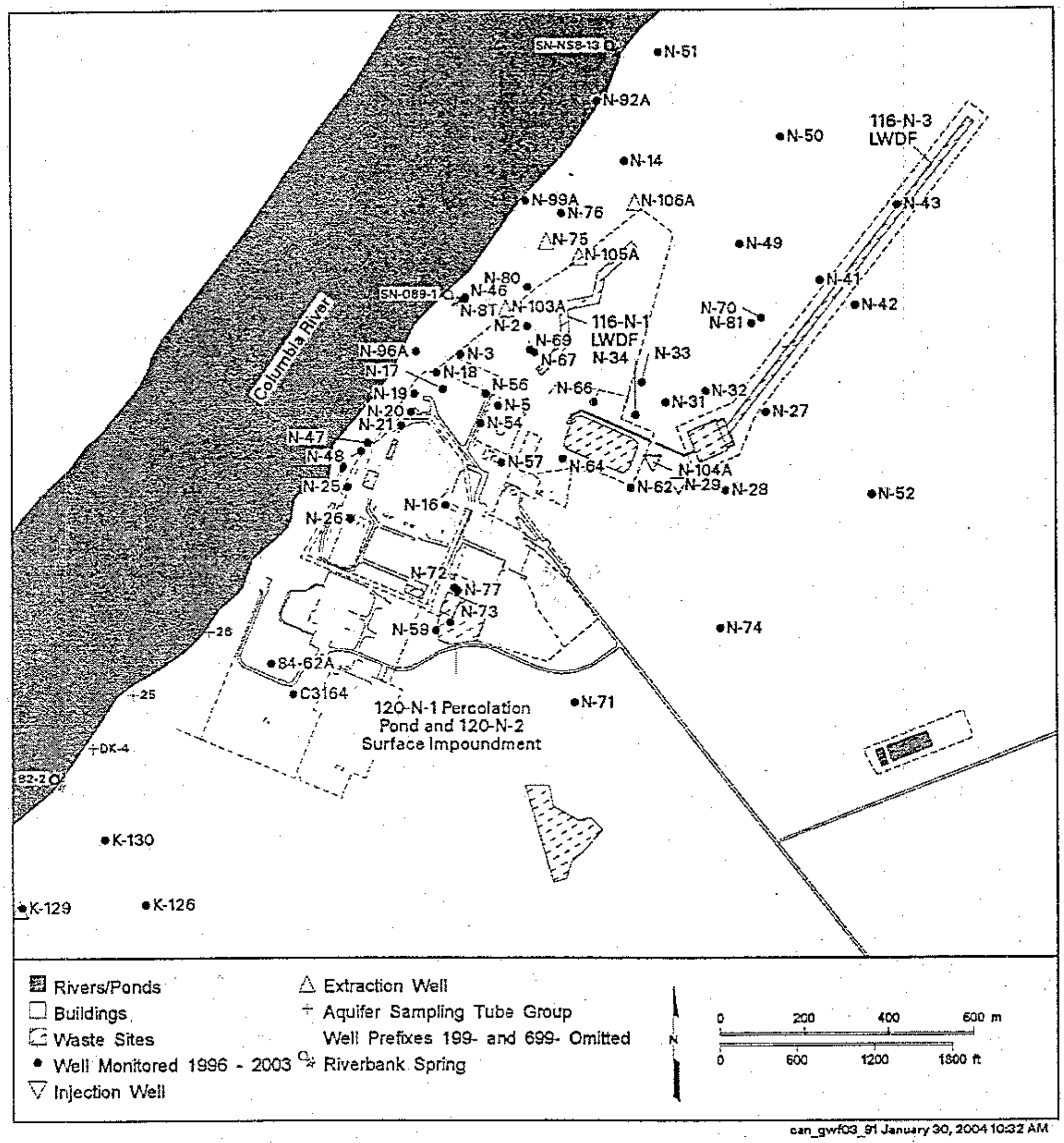

Figure 1.1. Groundwater Monitoring Wells in 100-N Area

1.1 Waste Characteristics

The effluent discharged to the 1324-N and 1324-NA units originated at the 163-N Demineralizer Plant and the 183-N Filtered Water Plant. Neither effluent stream contained listed constituents (WAC 173-303-090). However, effluent from the demineralizer plant was classified as corrosive dangerous waste (see current Part A permit application for the TSD units). Table 1.1 contains selected results of chemical analyses of effluent streams while the units were in use.

Table 1.1. Selected Results of Waste Analysis of 163-N Demineralization Plant Effluent, August 1987, and 183-N Filtered Water Plant Backwash Effluent, August 1985 (from Appendix B of DOE 2002)

Parameter (minimum detection limit, units)	163-N Demineralization Plant (corrosive waste)[a]	183-N Filtered Water Plant (non-dangerous effluent)[b]
Calcium (0.05 mg/L)	318.3/ND	17.4
Chloride (0.5 mg/L)	1.9/2.4	2.81
pH (standard units)	0.917/13.74	7.46
Potassium (0.1 mg/L)	14.2/26.7	0.792
Nitrate (0.5 mg/L)	0.8/1.1	0.596
Sodium (0.1 mg/L)	12.8/27,150	2.23
Sulfate (0.5 mg/L)	3,201/30.7	19.7
Specific Conductance (μS/cm)	37,367/64,000	153

(a) Average for cation regeneration cycle/Average for anion regeneration cycle.
(b) Average.
ND = not detected

The dangerous waste treated and disposed of at these units was produced by the regeneration of ion exchange columns in the 163-N Demineralizer Plant. The waste consisted of acid and caustic regeneration fluids and process and cooling water flushes. The pH of the demineralized water plant waste varied from less than 1.0 to as high as 14 standard units. These discharges qualified as corrosive dangerous waste defined in WAC 173-303-090(6)(a)(i). The regeneration solutions would have contained a variety of metal constituents as a result of concentration on the ion exchange media. These metals were not detected at levels that would regulate them as characteristic waste (WAC 173-303-090).

1.2 Post-Closure Monitoring Approach

Post-closure monitoring at the 1324-N and 1324-NA units has been developed to meet the standards for a corrective-action monitoring program under WAC 173-303-645(11). The interim remedial action record of decision for the 100-NR-1 and 100-NR-2 Operable Units (ROD 1999) explains that, "It is the intent of the Tri-Parties to select the same remedy for sites requiring RCRA corrective action as selected for those sites requiring *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) interim remedial actions." Until a final decision on remedial action of the sulfate plume is made for the 100-NR-2 Operable Unit, the plume will attenuate due to spreading, movement, and chemical interaction with sediment. RCRA groundwater monitoring during this initial period of post-closure monitoring will focus on defining sulfate concentration trends and plume extent, and comparing concentrations to the 250-mg/L secondary drinking water standard. This objective complements operable unit monitoring, which includes an objective to "...further define the extent and nature of contaminant plumes for the other contaminants of concern, [including] sulfate.... This... objective will provide information that can be used to help determine a final groundwater remedial action...." (ROD 1999).

1.3 Summary of Previous RCRA Groundwater Monitoring

RCRA groundwater monitoring at the 1324-N and 1324-NA site began in December 1987. After the first year of background monitoring, the critical mean value for specific conductance was exceeded in all downgradient wells then in use (199-N-58 through 199-N-61). The site was monitored under an interim status assessment program from 1989 until 1992. The assessment report (Hartman 1992) concluded that the elevated specific conductance was due to sulfate and sodium. From 1993 until 1995, the site was monitored under another interim status assessment program for elevated total organic halides. The associated assessment report (Hartman 1995) concluded that elevated total organic halides originated from nondangerous discharges to a nearby facility, and interim status indicator-evaluation monitoring resumed. Total organic halide levels subsequently declined to background, but specific conductance in downgradient wells continues to exceed the critical mean value.

When 1324-N and 1324-NA were incorporated into the Hanford Facility RCRA Permit in 1999, monitoring continued under the existing interim-status plan (Borghese et al. 1996 with details in Hartman 1996 and subsequently in Hartman 2002). Interim-status indicator evaluation monitoring continued before and during the closure period.

Groundwater monitoring shows the continued presence of elevated sulfate and sodium, with correspondingly high specific conductance. The sulfate plume extends toward the Columbia River (Figure 1.2). Only well 199-N-59 exceeded the secondary drinking water standard for sulfate (250 mg/L) in fiscal years 2001 or 2002. The maximum sulfate concentration in this well during fiscal year 2002 was 384 mg/L. Well 199-N-59 could not be sampled in fiscal years 2003 or 2004 because it was dry. Sulfate concentrations have been below the primary drinking water standard (500 mg/L) in all wells since 1991.

While the 1324-NA Percolation Pond was in use, sulfate concentrations in adjacent wells reached peaks of 1,500 to greater than 2,000 mg/L. Well 199-N-59 is the only original monitoring well that did not go dry in 1990. Sulfate concentrations in this well declined sharply after discharges ceased in 1990 (Figure 1.3) and occasionally were below the drinking water standard between 1991 and 1995. After 1995, sulfate levels gradually rose and stabilized at ~300 mg/L in well 199-N-59.

Sulfate trends in wells 199-N-72 and 199-N-73, installed in 1991, were relatively low during the first two to three years of monitoring, then sharply increased, peaking around 1995 (Figure 1.4). Levels have declined steadily since then. Sulfate concentrations currently are lower in these wells than in well 199-N-59. These differences may reflect vertical or horizontal heterogeneities in the sulfate plume.

Nitrate is elevated in groundwater beneath several portions of 100-N Area, including the 1324-N and 1324-NA site (Figure 1.5). The source is not believed to be the 1324-N or 1324-NA units because analysis of waste while the units were in use showed only low concentrations of nitrate (see Table 1.1). Nitrate concentrations also were low in groundwater samples collected before 1991 while the 1324-NA Percolation Pond was in use (Figure 1.6).

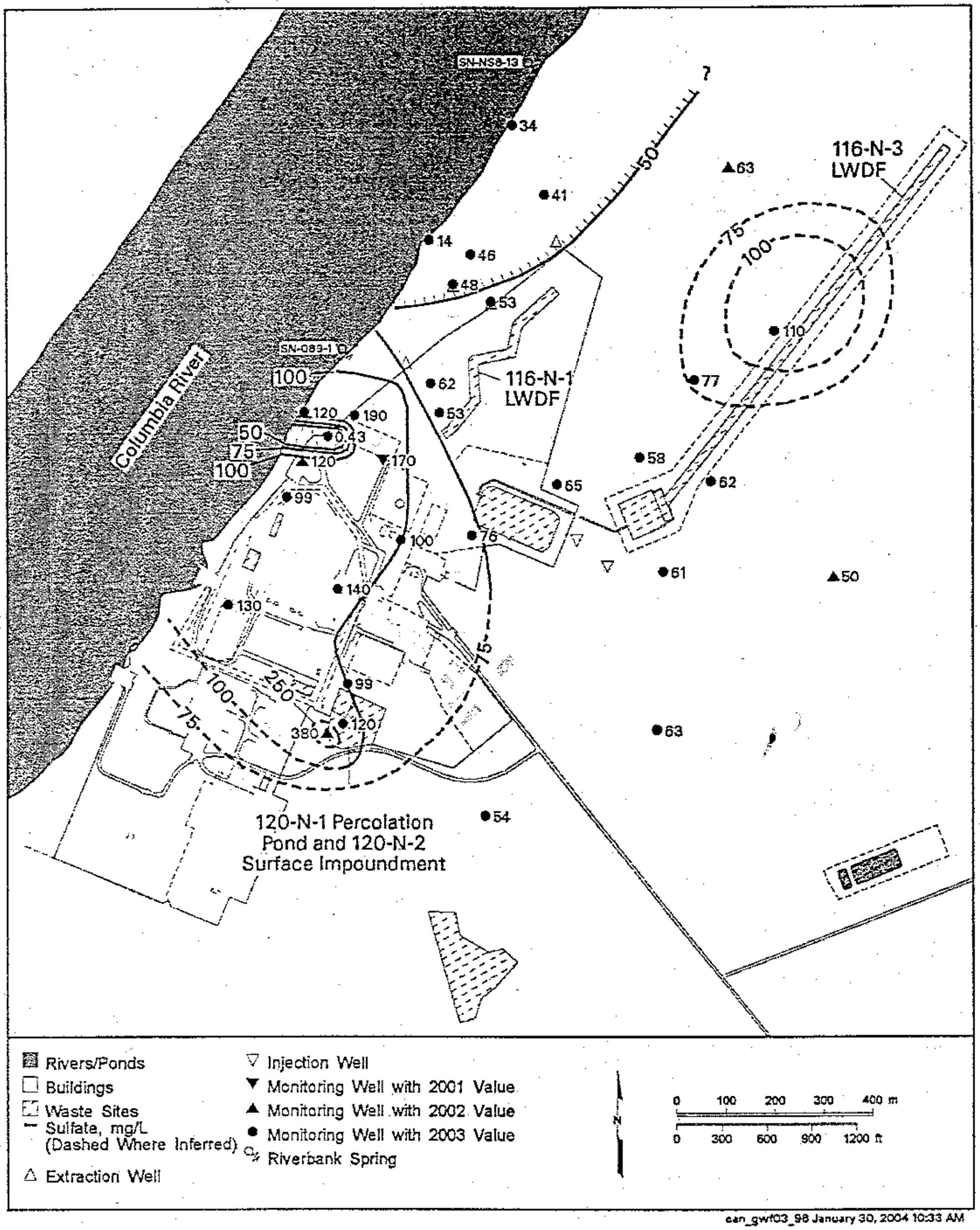

Figure 1.2. Average Sulfate Concentrations in 100-N Area

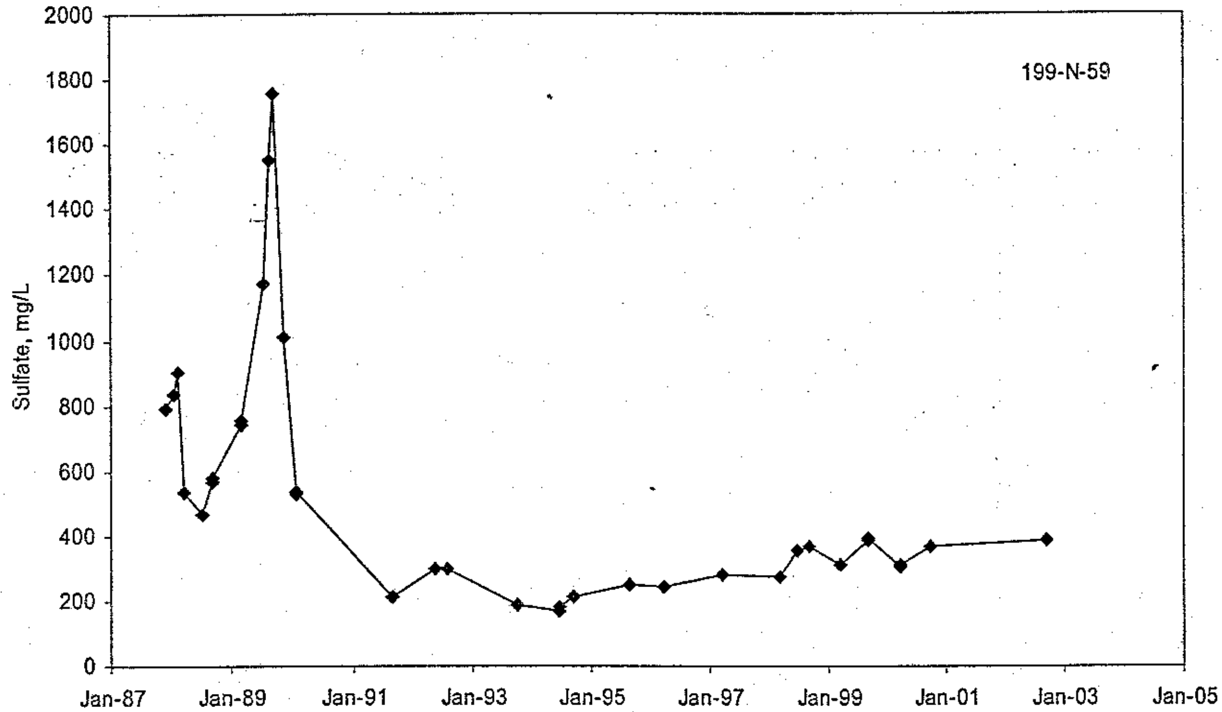

Figure 1.3. Long-Term Sulfate Trend in Well 199-N-59, Monitoring 1324-N and 1324-NA Units

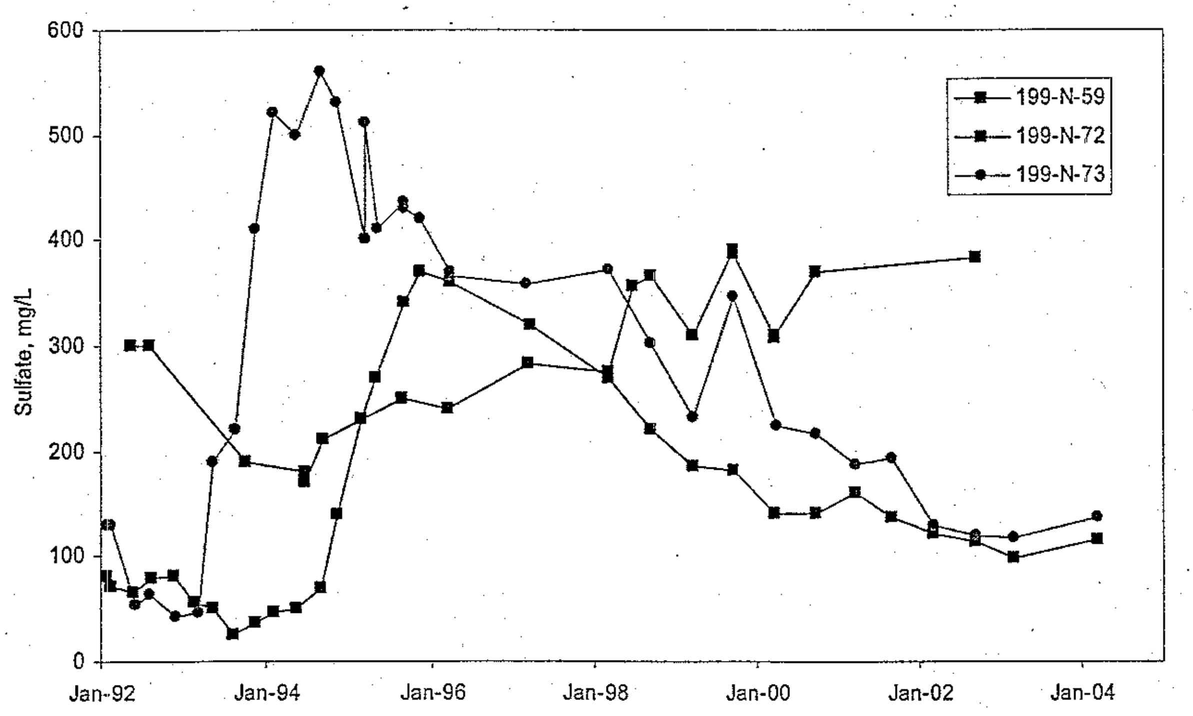

Figure 1.4. Sulfate Trends in Wells 199-N-59, 199-N-72, and 199-N-73, Monitoring 1324-N and 1324-NA Units

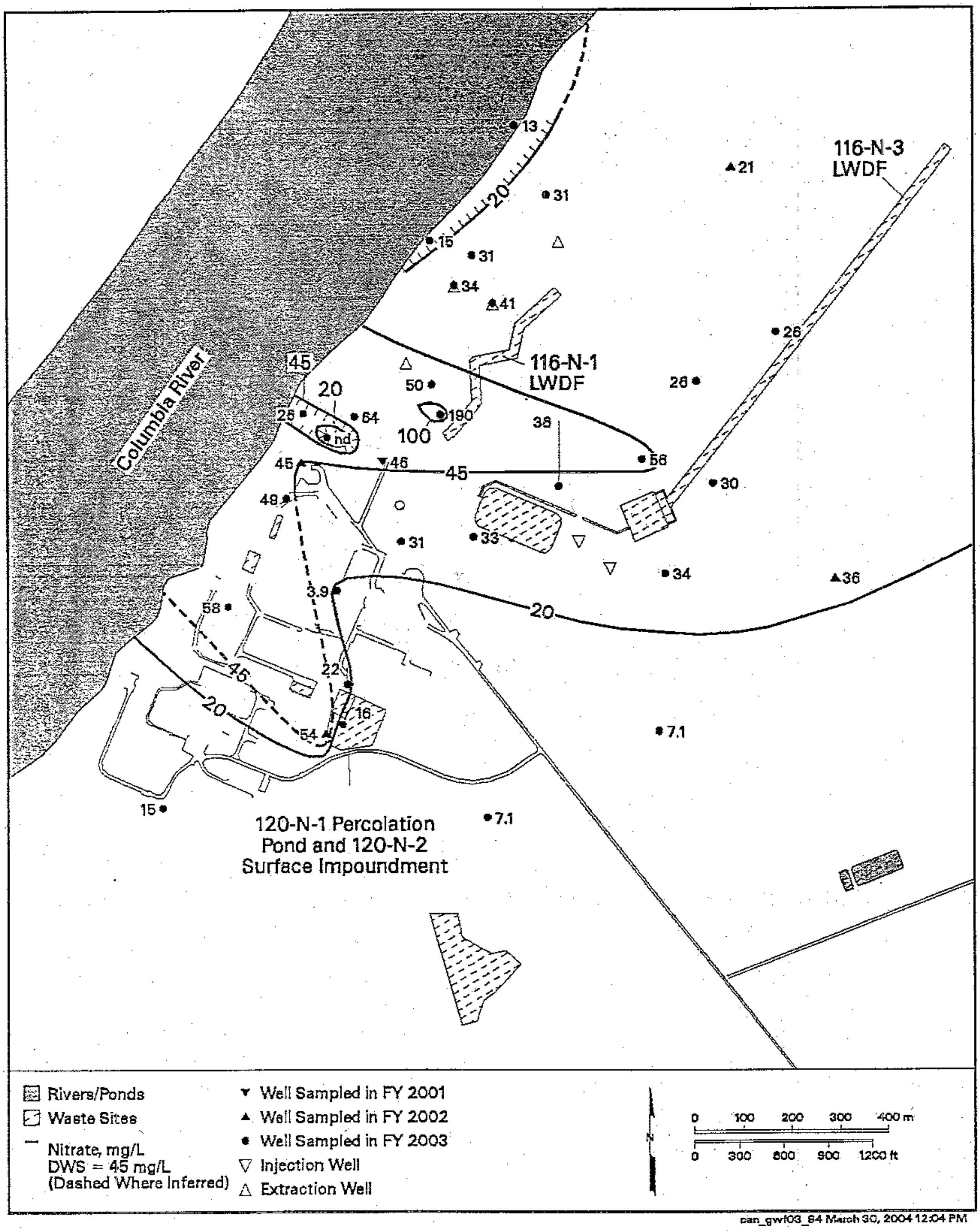

Figure 1.5. Average Nitrate Concentrations in 100-N Area

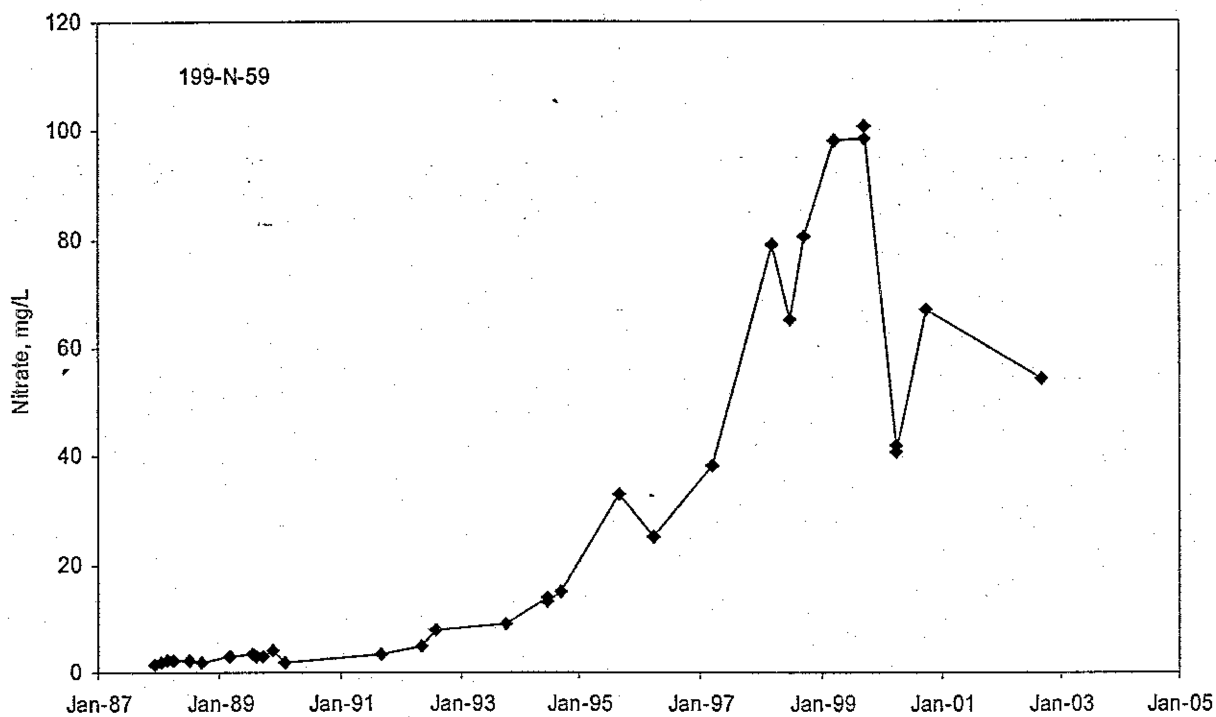

Figure 1.6. Long-Term Nitrate Trend in Well 199-N-59, Monitoring 1324-N and 1324-NA Units

2.0 Conceptual Model

A groundwater conceptual model is an evolving hypothesis that identifies the important features, events, and processes that control groundwater and contaminant movement. This model is based on results of previous geological and hydrogeological studies, sediment sampling, and groundwater monitoring. Primary references are Hartman and Lindsey (1993), Gilmore et al. (1992), DOE (2002), and groundwater monitoring annual reports (e.g., Hartman et al. 2003). The model provides a basis for designing a groundwater monitoring project.

The conceptual model for the 1324-N and 1324-NA units includes the following elements:

- The uppermost aquifer is unconfined, ~12-15 meters thick, and is contained in a sand and gravel unit in the Ringold Formation. Gilmore et al. (1992) estimated a representative range of transmissivity for the 100-N Area to be 93 to 560 m^2/d.

- The base of the uppermost aquifer is a fine-grained unit of interbedded silt and clay. The existence of deeper confined aquifers in the Ringold sediment and in the basalt-confined aquifer system is inferred on the basis of geologic interpretation and limited borehole data from the surrounding area, but there is little potential for downward migration of 100-N Area contaminants.

- Because the site has been backfilled and revegetated, most of the precipitation is removed by evapotranspiration. Thus, little infiltration will occur through the site.

- The 1324-N Surface Impoundment did not leak and, therefore, did not contaminate the vadose zone or groundwater.

- The 1324-NA Percolation Pond introduced ~~nonhazardous contaminants, primarily~~ sulfate and sodium~~,~~ through the vadose zone to groundwater. The pH of the effluent ranged from 1 to 14, causing it to be classified as hazardous, but mixing in the pond and neutralization in the sediment prevented the high-pH or low-pH water from reaching groundwater.

- While the percolation pond was active, artificial recharge formed a groundwater mound that created radial flow. Chemical impacts from the pond discharge migrated an unknown distance inland. After use of the pond ceased, groundwater flow returned to a northwest or north direction.

- Sulfate and sodium move readily with groundwater toward the north and northwest to the Columbia River. There appears to be continuing drainage of water from the vadose zone, since concentrations remain high many years after disposal ceased. These constituents cause the groundwater to have a high specific conductance.

- Sodium exchanges for calcium in vadose and aquifer sediments, which causes sodium concentrations in groundwater to decline while calcium concentrations increase as the water moves downgradient.

3.0 Groundwater Monitoring Program

This section describes the post-closure RCRA monitoring program for the 1324-N and 1324-NA units. The objective of monitoring is to track plume extent and contaminant trends until final cleanup decisions are made. The choices of wells, analyses, and sampling frequency included in this plan were~~are~~ based on data quality objectives as described in *Guidance for the Data Quality Objectives Process*, EPA/600/R-96/055 (QA/G-4), 2000 as revised.

3.1 Monitoring Well Network

The post-closure monitoring network (Table 3.1) includes:

- Four near-field wells adjacent to 1324-N and 1324-NA (199-N-59, 199-N-72, 199-N-73, and 199-N-77) to track concentration trends in the area of highest contamination.
- One upgradient well to provide information on groundwater quality not affected by 1324-N or 1324-NA.
- Eleven wells farther downgradient of the facilities to define the sulfate plume at levels below the secondary drinking water standard.

~~Data from additional wells that are sampled for the objectives of other RCRA units, 100-NR-2 Operable Unit, or the *Atomic Energy Act*, will be used to define and track the sulfate plume at levels below the secondary drinking water standard.~~

All of the wells except 199-N-77 monitor the top of the unconfined aquifer. Well 199-N-77 monitors the bottom of the unconfined aquifer, with the screen placed above a fine-grained unit in the Ringold Formation. As-built diagrams of the wells are included in the Appendix. ~~but are not considered an element to be incorporated into the Hanford Facility RCRA Permit.~~

If a monitoring well becomes unsuitable for use, Washington State Department of Ecology (Ecology) will be notified in writing. The monitoring program will be re-evaluated to determine if a new or existing well should be substituted. If a new well must be installed, it will be incorporated into the M-24 priority list.

3.2 Constituent List and Sampling Frequency

Sulfate and sodium are the primary constituents of interest for 1324-N and 1324-NA RCRA groundwater monitoring. Additional constituents will continue to be monitored for supporting information (see Table 3.1).

The downgradient, near-field wells will be sampled semiannually to provide a clear record of chemistry trends. ~~The upgradient well~~Other wells will be sampled annually (see Table 3.1)~~.~~

Table 3.1 Wells for Post-Closure Monitoring at the 1324-N and 1324-NA Units.

			Primary Constituents		Constituents Supporting Interpretation			Field Parameters				
Well	Purpose: Comments	Well Standard[a]	Sulfate	Sodium	Alkalinity	Anions[b]	Metals, filtered[c]	Specific Conductance	pH	Temperature	Turbidity	Water Levels
199-N-2	Far-field plume definition	PRE	A	A	A	A	A	A	A	A	A	A
199-N-3	Far-field plume definition	PRE	A	A	A	A	A	A	A	A	A	A
199-N-16	Far-field plume definition	PRE	A	A	A	A	A	A	A	A	A	A
199-N-19[d]	Far-field plume definition	PRE	A	A	A	A	A	A	A	A	A	A
199-N-21[d]	Far-field plume definition	PRE	A	A	A	A	A	A	A	A	A	A
199-N-26[d]	Far-field plume definition	PRE	A	A	A	A	A	A	A	A	A	A
199-N-34	Far-field plume definition	PRE	A	A	A	A	A	A	A	A	A	A
199-N-56	Far-field plume definition	WAC	A	A	A	A	A	A	A	A	A	A
199-N-57	Far-field plume definition	WAC	A	A	A	A	A	A	A	A	A	A
199-N-59	Near-field plume; sometimes dry[e]; highest sulfate concentrations	WAC	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
199-N-64	Far-field plume definition	WAC	A	A	A	A	A	A	A	A	A	A
199-N-67	Far-field plume definition	WAC	A	A	A	A	A	A	A	A	A	A
199-N-71	Upgradient	WAC	A	A	A	A	A	A	A	A	A	A
199-N-72	Near-field plume	WAC	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
199-N-73	Near-field plume	WAC	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
199-N-77	Near-field plume; bottom of aquifer	WAC	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA

(a) PRE = Well not constructed to Washington Administrative Code (WAC 173-160) standards.
WAC = Well constructed to Washington Administrative Code (WAC 173-160) standards.
(b) Anions analysis includes at a minimum chloride, nitrate, and sulfate.
(c) Metals analysis includes at a minimum calcium, magnesium, potassium, and sodium. Analyses will be run on filtered samples pending Ecology's policy decision on filtered/unfiltered metals.
(d) Candidates for decommissioning. If any of these wells are decommissioned, Ecology will be notified and the monitoring program will be reevaluated to determine if new well(s) are needed.
(e) Well 199-N-59 was drilled when the 1324-NA pond had artificially raised the water table. When the water table is low, it does not contain enough water to sample.

3.3 Water Level Monitoring

~~Samplers measure depth to water in each well before sampling, according to a subcontractor procedure.~~ Field personnel measure depth to water before sampling, or at other times as specified by the groundwater project (e.g., annual water-level measurements). The tapes used to make depth measurements are ~~periodically~~ periodically calibrated. Field personnel obtain two consecutive measurements that agree within 6 mm (0.02 feet) and record them along with date, time, measuring tape number, and other pertinent information. ~~The d~~Depth to water is subtracted from the elevation of a reference point (usually top of casing) to obtain water-level elevation. Water-level elevations are used to construct water-table maps of 100-N Area.

Groundwater flow direction beneath the 1324-N and 1324-NA units is inferred from the water-table map(s) and plume maps. Rate of flow is estimated from hydraulic gradient, hydraulic conductivity, and porosity or from rates of contaminant movement.

3.4 Sampling and Analysis Protocol

RCRA groundwater monitoring for the 1324-N and 1324-NA units is part of Hanford's groundwater project and follows ~~the~~ project~~'s~~ quality assurance protocols~~plan~~. Groundwater monitoring for these units will follow the requirements of the most recent revision of the project quality assurance ~~project plan~~protocols; this monitoring plan need not be revised to cite future revisions of ~~the quality assurance plan~~those protocols.

Project staff schedule sampling and initiate paperwork~~. The project uses subcontractors~~ and oversee ~~for~~ sample collection, shipping, and analysis. Quality requirements for ~~the~~ any~~subcontracted~~ work subcontracted are specified in statements of work or contracts.

The statement of work for sampling activities specifies that those activities will be conducted ~~shall be~~ in accordance with a quality assurance project plan that meets the requirements defined in *Requirements for Quality Assurance Project Plans,* EPA/240/B-01/003 (EPA QA/R-5), March 2001 as revised. Additional requirements are specified in the statement of work.

Groundwater project staff conduct laboratory audits and field surveillances to assess the quality of subcontracted work and initiate corrective action if needed.

3.4.1 Scheduling Groundwater Sampling

The groundwater project schedules well sampling. Many Hanford Site wells are sampled for multiple objectives and requirements; e.g., RCRA, CERCLA, and AEA. Scheduling activities help manage the overlap, eliminating redundant sampling and meeting the needs of each sampling objective. Scheduling activities include the following:

- Each fiscal year, project scientists provide well lists, constituent lists, and sampling frequency. Each month, project scientists review the sampling schedule for the following month. Changes are requested via change request forms and approved by the sampling and analysis task lead and monitoring project manager.

- Project staff track sampling and analysis through an electronic schedule database stored on a server at PNNL. Quality control samples also are managed through this database. A scheduling program generates unique sample numbers, and a special user interface generates sample authorization forms, field services reports, groundwater sample reports, chain-of-custody forms, and sample container labels.

- Sampling and analysis staff verify that ~~such things as~~ well name, sample numbers, bottle sizes, ~~and~~ preservatives, etc. are indicated properly on the paperwork, which is transmitted to the ~~sampling~~

~~subcontractor~~sample collector. Staff ~~complete a checklist to document that~~verify that the paperwork was generated correctly.

- At each month's end, project staff use the schedule database to determine if any wells were not sampled as scheduled. If the wells or sampling pumps require maintenance, ~~it~~ sampling is rescheduled following repair. If a well can no longer be sampled it is cancelled, and the reason is recorded in the database. DOE will notify Ecology if sampling is delayed past the end of the scheduled quarter or if a well cannot be sampled (see Sections 3.1 and 5.4). Should repairs require an extended effort (more than 60 days), Ecology will be consulted and a repair schedule approved.

3.4.2 Chain of Custody

The ~~sampling subcontractor~~ sample collector uses chain-of-custody forms to document the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during scheduling (see Section 3.4.1) and managed ~~through a subcontractor procedure~~by the sample collector. Samplers enter required information on the forms, including the following:

- Sampler's name(s)
- Method of shipment and destination
- Collection date and time
- Sample identification numbers
- Analysis methods
- Preservation methods.

When samples are transferred from one custodian to another (e.g., from sampler to shipper or shipper to analytical laboratory), the receiving custodian inspects the form and samples and notes any deficiencies. Each transfer of custody is documented by the printed names and signatures of the custodian relinquishing the samples and the custodian receiving the samples, and the time and date of transfer.

3.4.3 Sample Collection

All of the wells in the 1324-N/NA network are equipped with dedicated sampling pumps. Field personnel measure water levels in each well prior to sampling (see Section 3.3), then purge stagnant water from the well. Groundwater samples ~~are collected according to subcontractor's procedures. Samples~~ generally are collected after three casing volumes of water have been purged from the well or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized~~i.e., after two consecutive measurements are within 0.2 units pH, 0.2°C for temperature, 10% for specific conductance, and turbidity <5 nephelometric turbidity units (NTU)]~~.

For routine groundwater samples, preservatives are added to the collection bottles, if necessary, before their use in the field. Samples for metals analyses ~~will be~~ are filtered in the field with 0.45micrometer, in-line, disposable filters. After sampling, pH, temperature and specific conductance are measured again. Sample bottles are sealed with evidence tape and placed in a cooler with ice for shipping.

The samplers record the date, time, personnel, field measurements, and other pertinent information and complete the chain of custody form as described in Section 3.4.2.

3.4.4 Analytical Protocols

Instruments for f~~Procedures for field measurements are specified in subcontractor's procedures.~~ ield measurements (e.g., pH, specific conductance, temperature, and turbidity) are calibrated using standard solutions prior to use ~~and are operated according to manufacturer's instructions~~ and are operated according to manufacturer's instructions. Each instrument is assigned a unique number that is tracked on field documentation and calibrated and controlled ~~according to procedure.~~ ~~Additional calibration and use instructions are specified in the instrument user manuals.~~

Laboratory analytical methods are specified in contracts with the laboratories, and are standard methods from *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846 as amended) or *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020, 1983).

4.0 Quality Assurance

The groundwater project's quality assurance ~~plan~~ protocols meets *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003 (EPA QA/R-5), March 2001 as revised. A quality control ~~plan~~ protocol is included in the groundwater project quality ~~assurance plan~~documentation, and quality control sampling requirements for subcontracted work are discussed in the statement of work with the subcontractor.

The groundwater project's quality control program is designed to assess and enhance the reliability and validity of groundwater data. This is accomplished through evaluating the results of quality control samples, conducting audits, and validating groundwater data. This section describes the quality control program for the entire groundwater project, which includes 1324-N and 1324-NA units. The quality control practices of the groundwater project are based on EPA guidance ~~from the EPA as described~~cited in the *Tri-Party Agreement Action Plan*, Section 6.5 (Ecology, et al., 1998). Accuracy, precision, and detection are the primary parameters used to assess data quality (Mitchell et al. 1985). Data for these parameters are obtained from two categories of quality control samples: those that provide checks on field and laboratory activities (field quality control) and those that monitor laboratory performance (laboratory quality control). Table 4.1 summarizes the types of samples in each category and the sample frequencies and characteristics evaluated.

Table 4.1. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field Quality Control		
Full Trip Blank	Contamination from containers or transportation	1 per 20 well trips
Field Transfer Blank[(a)]	Airborne contamination from the sampling site	1 each day volatile organic compound samples are collected
Equipment Blank[(b)]	Contamination from nondedicated sampling equipment	1 per 10 well trips or as needed[(c)]
Duplicate Samples	Reproducibility	1 per 20 well trips
Laboratory Quality Control		
Method Blank	Laboratory contamination	1 per batch
Lab Duplicates	Laboratory reproducibility	Method/contract specific[(d)]
Matrix Spike	Matrix effects and laboratory accuracy	Method/contract specific[(d)]
Matrix Spike Duplicate	Laboratory reproducibility and accuracy	Method/contract specific[(d)]
Surrogates	Recovery/yield	Method/contract specific[(d)]
Laboratory Control Sample	Accuracy	1 per batch
Double Blind Standards	Accuracy and precision	Varies by constituent[(e)]

(a) Not applicable for 1324-N and 1324-NA – no volatile constituents analyzed.
(b) Not applicable for 1324-N and 1324-NA – dedicated sampling equipment used.
(c) When a new type of non-dedicated sampling equipment is used, an equipment blank should be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the equipment's decontamination procedure.
(d) If called for by the analytical method, duplicates, matrix spikes, and matrix spike duplicates are typically analyzed at a frequency of 1 per 20 samples. Surrogates are routinely included in every sample for most gas chromatographic methods.
(e) Double blind standards containing known concentrations of selected analytes are typically submitted in triplicate or quadruplicate on a quarterly, semi-annual, or annual basis.

4.1 Quality Control Criteria

Quality control data are evaluated based on established acceptance criteria for each quality control sample type. For field and method blanks, the acceptance limit is generally two times the instrument detection limit (metals), or method detection limit (other chemical parameters). However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, and phthalate esters, the limit is five times the method detection limit. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are flagged with a "Q" in the database to indicate a potential contamination problem.

Field duplicates must agree within 20%, as measured by the relative percent difference (RPD), to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results are also flagged with a "Q" in the database.

The acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are generally derived from historical data at the laboratories in accordance with *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846 as amended). Typical acceptance limits are within 25% of the expected values, although the limits may vary considerably with the method and analyte. Current values for laboratory duplicates, matrix spikes, and laboratory control samples are 20% RPD, 60%-140%, and 70%-130%, respectively. These values are subject to change if the contract is modified or replaced.

Table 4.2 lists the acceptable recovery limits for the double blind standards. These samples are prepared by spiking background well water (currently wells 699-19-88 and 699-49-100C) with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper limit of concentration determined in groundwater on the Hanford Site. Double blind standard results that are outside the acceptance limits are investigated, and appropriate actions are taken if necessary.

Holding time is the elapsed time period between sample collection and analysis. Exceeding recommended holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA/SW-846 as amended) or *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020, 1983). These h~~H~~olding times are specified in laboratory contracts. Data associated with exceeded holding times are flagged with an "H" in the Hanford Environmental Information System (HEIS) database.

Additional quality control measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. The groundwater project periodically audits the analytical laboratories to identify and solve quality problems, or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report.

Table 4.2. Recovery Limits for Double Blind Standards

Constituent	Frequency	Recovery Limits	Precision Limits (RSD)
Specific conductance	Quarterly	75–125%	25%
Nitrate	Quarterly	75–125%	25%
RSD = Relative Standard Deviation			

4.2 Groundwater Data Validation Process

The groundwater project's data validation process provides requirements and guidance for validation of groundwater data that are routinely collected as part of the groundwater project. Validation is a systematic process of reviewing data against a set of criteria to determine whether the data are acceptable for their intended use. This process applies to groundwater data that have been verified (see Section 5.1) and loaded into HEIS. The outcome of the activities described below is an electronic data set with suspect or erroneous data corrected or flagged. Groundwater project staff document the validation process quarterly ~~by signing a checklist, which~~. Documentation is stored in the project file.

Responsibilities for data validation are divided among project staff. Each RCRA unit or geographic region is assigned to a project scientist, who is familiar with the hydrogeologic conditions of that site. The data validation process includes the following elements.

- **Generation of data reports:** Twice each month, data management staff provide tables of newly loaded data to project scientists for evaluation (biweekly reports). Also, after laboratory results from a reporting quarter have been loaded into HEIS, staff produce tables of water-level data and analytical data for wells sampled within that quarter (quarterly reports). The quarterly data reports include any data flags added during the quality control evaluation or as a result of prior data review.

- **Project scientist evaluation:** As soon as practical after receiving biweekly reports, project scientists review the data to identify changes in groundwater quality or potential data errors. Evaluation techniques include comparing key constituents to historical trends or spatial patterns. Other data checks may include comparison of general parameters to their specific counterparts (e.g., conductivity to ions) and calculation of charge balances. Project scientists request data reviews if appropriate (see Section 5.2). If necessary, the laboratory may be asked to check calculations or reanalyze the sample, or the well may be resampled. After receiving quarterly reports, project scientists review sampling summary tables to determine whether network wells were sampled and analyzed as scheduled. If not, they work with other project staff to resolve the problem. Project scientists also review quarterly reports of analytical and water-level data using the same techniques as for biweekly reports. Unlike the biweekly reports, the quarterly reports usually include a full data set (i.e., all the data from the wells sampled during the previous quarter have been received and loaded into HEIS).

- Staff report results of quality control evaluations informally to project staff, DOE~~-Pacific Northwest Site Office (PNSO)~~, and Ecology each quarter. Results for each fiscal year are described in the annual groundwater monitoring report.

5.0 Data Management and Reporting

This section describes how groundwater data are stored, retrieved, and interpreted.

5.1 Loading and Verifying Data

The contract laboratories report analytical results electronically and in hard copy. The electronic results are loaded into HEIS. Hard copy data reports and field records are maintained as part of the Hanford Facility operating record, unit specific file for the TSD unit.. Project staff perform an array of computer checks on the electronic file for formatting, allowed values, data flagging (qualifiers), and completeness. Verification of the hard copy results includes checks for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems that arose during the analysis of the samples, and (4) correct reporting of results. If data are incomplete or deficient, staff work with the laboratory to get the problems corrected. Notes on condition of samples or problems during analysis may be used to support data reviews (see Section 5.2).

Field data such as specific conductance, pH, temperature, turbidity, and depth-to-water are recorded on field records. Data management staff enter these into HEIS manually through data-entry screens, verify each value against the hard copy, and initial each value on the hard copy.

5.2 Data Review

The groundwater project conducts special reviews of groundwater analytical data or field measurements when results are in question. Groundwater project staff document the process on a review form, and results are used to flag the data appropriately in HEIS. Various staff may initiate a review form: e.g., project scientists, data management staff, and quality control staff. The data review process includes the following steps:

- The initiator fills out required information on the review form, such as sample number, constituent, and reason for the request (e.g., "result is two orders of magnitude greater than historical results and disagrees with duplicate"). The initiator recommends an action, such as a data re-check, sample re-analysis, well re-sampling, or simply flagging the data as suspect in HEIS.

- The data review coordinator determines that the review form does not duplicate a previously submitted review form, then assigns a unique review form number and records it on the form. A temporary flag is assigned to the data in HEIS indicating the data are undergoing review ("F" flag).

- If laboratory action is required, the data review coordinator records the laboratory's response on the review form. Other documentation also may be relevant, such as chain-of-custody forms, field records, calibration logs, or chemist's sheets.

- A project scientist assigned to examine a review form determines and records the appropriate response and action on the review form including changes to be made to the data flags in HEIS. Actions may include updating HEIS with corrected data or result of re-analysis, flagging existing data (e.g., "R" for reject, "Y" for suspect, "G" for good), and/or adding comments. Data management staff updates the temporary "F" flag to the final flag in HEIS.

- The data review coordinator signs the review form to indicate its closure.

- If a review form is filed on data that are not "owned" by the groundwater project, the data review coordinator forwards a copy of the partially filled review form to the appropriate contact for their action. The review is then closed.

5.3 Interpretation

After data are validated and verified, the acceptable data are used to interpret groundwater conditions at the site. Interpretive techniques include:

- Hydrographs – graph water levels vs. time to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.

- Water-table maps – use water-table elevations from multiple wells to construct contour maps to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential.

- Trend plots – graph concentrations of constituents vs. time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.

- Plume maps – map distributions of chemical or radiological constituents in the aquifer to determine extent of contamination. Changes in plume distribution over time aid in determining movement of plumes and direction of flow.

- Contaminant ratios – can sometimes be used to distinguish between different sources of contamination.

5.4 Reporting

Reporting requirements for sites undergoing groundwater corrective action state that "The owner or operator must report in writing to the department on the effectiveness of the corrective action program... semiannually." This can be accomplished under the groundwater project's existing quarterly reports. The quarterly reports also inform Ecology if sampling is delayed past the end of the scheduled quarter. Chemistry and water-level data are reviewed after each sampling event and are available in HEIS. When needed, DOE will report specific incidents affecting 1324-N and 1324-NA groundwater monitoring (e.g., unsuitable wells, delayed sampling) as described in Sections 3.1 and 3.4.1.

6.0 References

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Appendix

As-Built Diagrams of Monitoring Wells

This appendix contains diagrams of wells in the 1324-N and 1324-NA RCRA groundwater monitoring network. The diagrams summarize stratigraphy and well construction materials. The diagrams are presented in numerical order.

Monitoring Wells for Post-Closure Monitoring at the 1324-N/NA Facilities.

Well	Purpose; comments
199-N-2	Far-field plume definition
199-N-3	Far-field plume definition
199-N-16	Far-field plume definition
199-N-19	Far-field plume definition
199-N-21	Far-field plume definition
199-N-26	Far-field plume definition
199-N-34	Far-field plume definition
199-N-56	Far-field plume definition
199-N-57	Far-field plume definition
199-N-59	Near-field plume; sometimes dry[(a)]; highest sulfate concentrations
199-N-64	Far-field plume definition
199-N-67	Far-field plume definition
199-N-71	Upgradient
199-N-72	Near-field plume
199-N-73	Near-field plume
199-N-77	Near-field plume; bottom of aquifer

(a) Well 199-N-59 was drilled when the 1324-NA pond had artificially raised the water table. When the water table is low, it does not contain enough water to sample.

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Water
Driller's Name: Rodda
Drilling Company: Bach Dilling Co.
Date Started: 25May64

Sample Method: Hard tool (nom)
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Not documented
Date Complete: 05Jun64

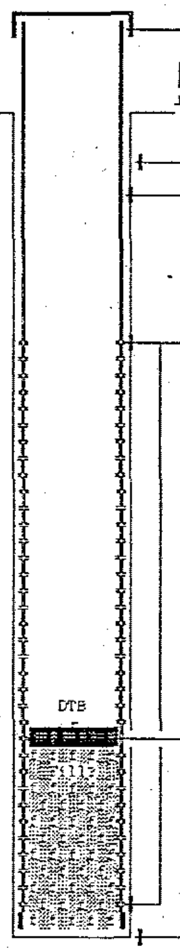
WELL NUMBER: 199-N-2 A4669 TEMPORARY WELL NO:
Hanford Coordinates: N/S N 86,577 E/W W 60,306
State NAD83 N 149,859.43m E 571,476.21m
Coordinates: N 491,724 E 2,234,797
Start Card #: Not documented T R S
Elevation Ground surface (ft): 457.1 Estimated

Depth to water: 60.0-ft Jun64
(Ground surface) 73.8-ft 13Sep94

GENERALIZED STRATIGRAPHY Driller's Log

0-8: SAND, GRAVEL & BOULDERS
8-15: SAND & GRAVEL
15-17: BOULDER
17-100: SAND & GRAVEL
100-105: GRAVEL, SAND & CLAY
105-135: CLAY

REMEDIATION:
24-30May78 by M. Bultena
Removed piezometers.
Brushed and cleaned.
Set cement plug at 95-ft.



Elevation of reference point: [459.13-ft]
(top of casing)
Height of reference point above [2.0-ft]
ground surface
Depth of surface seal [ND]
No surface seal documented
9-in nominal hole, 0-125-ft
8-in ID carbon steel casing, +2.0-125-ft
6-in casing perforations, 35-120-ft, 6 holes/rd/ft
Cement plug @ 95-ft
Borehole drilled depth: [125.0-ft]
DTB=Depth to bottom, 91.3-ft, 13Apr93

Drawing By: RKL/1-N-02.ASB
Date : 01Dec94
Reference : HANFORD WELLS

199-N-2

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Water
Driller's Name: Shafer
Drilling Company: Bach Dilling Co.
Date Started: 02Jun64

Sample Method: Hard tool (nom)
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Not documented
Date Complete: 12Jun64

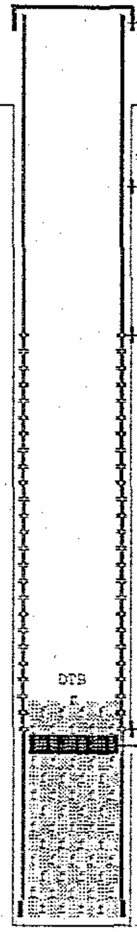
WELL NUMBER: 199-N-3 A4679 TEMPORARY WELL NO:
Hanford Coordinates: N/S N 86,365 E/W W 60,828
State NAD83 Coordinates: N 149,794.61m E 571,317.36m
N 491,511 E 2,234,277
Start Card #: Not documented T R S
Elevation Ground surface: 457.8-ft Estimated

Depth to water: 63.0-ft Jun64
(Ground surface) 73.8-ft 13Sep94

GENERALIZED STRATIGRAPHY Driller's Log

0-11: BOULDERS and DUST
11-15: BOULDERS and SAND
15-17: BOULDER, SAND and DUST
17-20: COBBLES and SAND
20-21: BOULDERS and SAND
21-22: BOULDERS and GRAVEL
22-63: SAND and GRAVEL
63-68: SAND
68-74: SAND and GRAVEL
74-76: SAND
76-98: SAND and GRAVEL
98-104: SAND
104-106: SAND and GRAVEL
106-125: Not documented

REMEDIATION:
Removal of piezometers and probable setting of plug not documented.



Elevation of reference point: [459.45-ft]
(top of casing)
Height of reference point above ground surface [1.7-ft]
Depth of surface seal [ND]
No surface seal documented,
9-in nominal hole, 0-125-ft
8-in ID carbon steel casing, +1.7-~125-ft
8-in casing perforations, 34-95-ft, cuts not documented
May have cement plug ~95-ft
Borehole drilled depth: [125.0-ft]
DTB=Depth to bottom, 91.4-ft, 28Jun94

Drawing By: RKL/1-N-03.ASB
Date : 01Dec94
Reference : HANFORD WELLS

199-N-3

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Rotary
Drilling Fluid Used: Air
Driller's Name: Nelson ?
Drilling Company: Nelson Well Drilling
Date Started: 09Feb81

Sample Method: Air returns
Additives Used: Foam, Torq Trim
WA State Lic Nr: Not documented
Company Location: Pasco, WA
Date Complete: 10Feb81

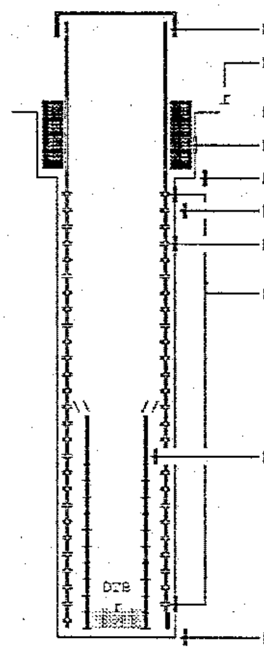
WELL NUMBER: 199-N-16 A4665 TEMPORARY WELL NO:
Hanford N-Area N 6,087 W 6,158
Coordinates: N/S N 85,207.94 E/W W 60,950.06
State NAD83 N 149,441.85m 571,281.37m
Coordinates: N 490,353 E 2,234,156
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 453.5-ft Estimated

Depth to water: 57.5-ft Feb81
(Ground surface) 68.9-ft 18Mar93

GENERALIZED STRATIGRAPHY — Driller's Log

0-4: GRAVEL and COBBLES with SILT
4-15: GRAVEL and COBBLES with BOULDERS, SAND
15-20: GRAVEL with SAND, COBBLES, and BOULDERS
20-40: GRAVEL and SAND
40-45: GRAVEL, COBBLES and SAND
45-79: GRAVEL and SAND
79-80: Not documented

REMEDIATION:
19-Apr84 by M. Bultena
Cleaned well. Installed telescoping screen.



Elevation of reference point: [456.70-ft]
(top of casing)

Height of reference point above [3.2-ft] ground surface

Depth of surface seal [10-ft nom]

Type of surface seal, Cement gorut to ~10-ft

ND-in hole, 0-10-ft

9-in nominal hole, 10-80-ft

8-in ID carbon steel casing, +3.2--80-ft

8-in casing perforations, 12-78-ft, cuts not documented

6-in nom stainless telescoping screen, 51.5-78.5-ft, #10-slot
7-ft of 5-in pipe with flare on top

Borehole drilled depth: [80.0-ft]

DTB-Depth to bottom, 78.3-ft, 11Aug92

Drawing By: RKL/1-N-16.ASB
Date : 07Dec94
Reference : HANFORD WELLS

199-N-16

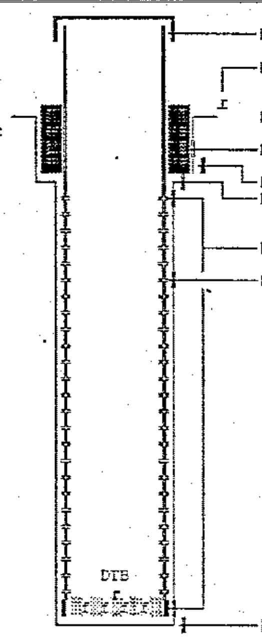
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Rotary	Sample Method: Air returns	WELL NUMBER: 199-N-19 A4668 TEMPORARY WELL NO:
Drilling Fluid Used: Air	Additives Used: Foam, Torq Trim	Hanford N-Area Coordinates: N/S N 6,783 N 86,063.69 E/W W 6,709 W 61,184.87
Driller's Name: Nelson ?	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 149,702.45m 491,208 E 571,209.05m 2,233,919
Drilling Company: Nelson Well Drilling	Company Location: Pasco, WA	Start Card #: Not documented T___ R___ S___
Date Started: 30Jan81	Date Complete: 30Jan81	Elevation Ground surface: 450.9-ft Estimated

Depth to water: Not documented
(Ground surface) 69.6-ft 13Sep94

GENERALIZED STRATIGRAPHY — Driller's Log

0-10: GRAVEL 6-in minus and COBBLES with SILT to 3-ft
10-15: GRAVEL 6-in minus with COBBLES, SAND and BOULDERS
15-20: GRAVEL 6-in minus some COBBLES, SAND
20-25: GRAVEL 6-in minus, some COBBLES, SAND
25-30: GRAVEL 6-in minus, SAND
30-45: GRAVEL 4-in minus, SAND
45-62: GRAVEL 6-in minus, SAND and COBBLES
62-64: GRAVEL 6-in minus, SAND and COBBLES
64-77: GRAVEL 6-in minus, SAND
77-78: SAND with GRAVEL



Elevation of reference point: (top of casing) [453.90-ft]
Height of reference point above ground surface [3.0-ft]
Depth of surface seal [10-ft nom]
Type of surface seal, Cement grout to ~10-ft (Not documented)
ND hole, 0-~10-ft (Not documented)
9-in nominal hole, ~10-78-ft
8-in casing perforations, 12-78-ft, cuts not documented
8-in ID carbon steel casing, +3.0-78-ft
Borehole drilled depth: [78.0-ft]
DTB=Depth to bottom, 76.8-ft, 05Aug92

Drawing By: RKL/1-N-19.ASB
Date : 07Dec94
Reference : HANFORD WELLS

199-N-19

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Rotary
Drilling Fluid Used: Air
Driller's Name: Nelson ?
Drilling Company: Nelson Well Drilling
Date Started: 16Jan81

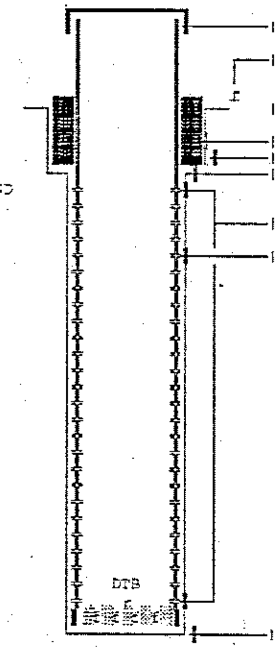
Sample Method: Air returns
Additives Used: Foam, Torq Trim
WA State Lic Nr: Not documented
Company Location: Pasco, WA
Date Complete: 20Jan81

WELL NUMBER: 199-N-21 A4671 TEMPORARY WELL NO:
Hanford N-Area N 6,522 W 6,707
Coordinates: N/S N 35,822.95 E/W W 61,284.66
State NAD83 N 149,629.41m E 571,177.78m
Coordinates: N 490,967 E 2,233,820
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 454.1-ft Estimated

Depth to water: 60.0-ft Jan81
(Ground surface) 71.8-ft 13Sep94

GENERALIZED STRATIGRAPHY Driller's Log

0-6: GRAVEL and COBBLES with SILT binder
6-9: BOULDER
9-15: COBBLES and GRAVEL
15-20: COBBLES and GRAVEL with SAND
20-25: COBBLES and GRAVEL, SAND with a trace of SILT
25-30: COBBLES, GRAVEL, SAND
30-40: GRAVEL 6-in minus, SAND
40-45: GRAVEL 4-in minus, SAND
45-55: GRAVEL 2-in minus, SAND
55-79.5: GRAVEL 6-in minus, SAND



Elevation of reference point: (top of casing) [457.00-ft]
Height of reference point above ground surface [2.9-ft]
Depth of surface seal [10-ft nom]
Type of surface seal, Cement grout to 10-ft
ND hole, 0-10-ft
9-in nominal hole, 10-79.5-ft
8-in casing perforations, 12-77.6-ft, cuts not documented
8-in ID carbon steel casing, +2.9-79.5-ft
Borehole drilled depth: [79.5-ft]
DTB-Depth to bottom, 77.2-ft, 09Oct92

Drawing By: RKL/1-N-21.ASB
Date : 09Dec94
Reference : HANFORD WELLS

199-N-21

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling
Method: Rotary
Drilling
Fluid Used: Air
Driller's
Name: Nelson ?
Drilling
Company: Nelson Well Drilling
Date
Started: 31Dec80

Sample
Method: Air returns
Additives
Used: Foam, Torq Trim
WA State
Lic Nr: Not documented
Company
Location: Pasco, WA
Date
Complete: 03Jan81

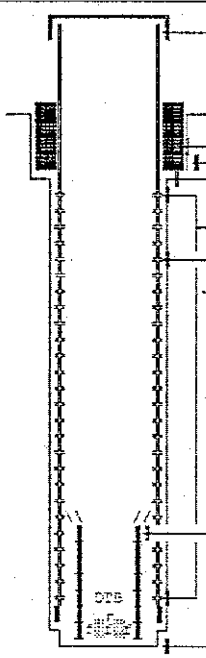
WELL
NUMBER: 199-N-26 A4675
TEMPORARY
WELL NO:
Hanford N-Area N 5,705 W 6,797
Coordinates: N/S N 65,105.38 E/W W 61,636.89
State NAD83 N 149,410.03m E 571,056.86m
Coordinates: N 490,249 E 2,233,420
Start
Card #: Not documented T___ R___ S___
Elevation
Ground surface: 453.1-ft Estimated

Depth to water: 63.0-ft Jan81
(top-of-casing) 72.1-ft 13Sep94

GENERALIZED STRATIGRAPHY Driller's Log

0-10: GRAVEL with COBBLES and SAND with SILT
10-15: GRAVEL with COBBLES and SAND
15-20: GRAVEL with some SAND
20-45: GRAVEL 6-in with SAND
45-50: GRAVEL 3-in with SAND, SILT
50-55: GRAVEL 3-in, COBBLES, SAND more SILT
55-79: GRAVEL 3-in, SAND silty

REMEDIATION:
23-24aApr84 by M. Bultena
Set telescoping screen



Elevation of reference point: [455.80-ft]
(top of casing)
Height of reference point above ground surface [2.7-ft]

Depth of surface seal [10-ft nom]
Type of surface seal,
Cement grout to 10-ft
ND hole, 0-10-ft
9-in nominal hole, 10--79-ft

8-in casing perforations,
12-77-ft, cuts not documented

8-in ID carbon steel casing, +2.7--79-ft

6-in stainless telescoping screen,
61.0-81.5-ft, #10-slot
w/1-ft flared 6-in casing on top

Borehole drilled depth: [~81.5-ft]

DTB=Depth to bottom,
78.3-ft, 17Feb93

Drawing By: RKL/1-N-26.ASB
Date : 09Dec94
Reference : HANFORD WELLS

199-N-26

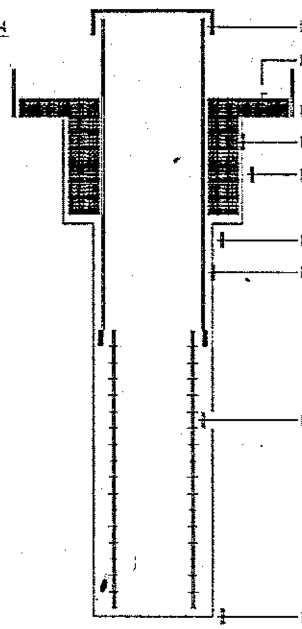
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 199-N-34 A4683 TEMPORARY WELL NO:
Drilling Fluid Used: Not documented	Additives Used: Not documented	Hanford N-Area N 7,309 W 5,049 Coordinates: N/S N 95,899.07 E/W W 59,451.54
Driller's Name: Bultena	WA State Lic Nr: 0066	State NAD83 N 149,653.89m E 571,737.41m Coordinates: N 491,048 E 2,235,653
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 01Sep83	Date Complete: 09Sep83	Elevation Ground surface (ft): 459.6 Estimated

Depth to water: ~59.0-ft Sep83
(Ground surface) 71.3-ft 12Sep94

GENERALIZED STRATIGRAPHY   Driller's Log

0-50: COBBLES and BOULDERS
50-78: COBBLES, SAND and SILT



Elevation of reference point: [459.63-ft]
(top of casing)
Height of reference point above [2.0-ft]
ground surface
Depth of surface seal [0--18-ft]
Type of surface seal,
Cement grout to -18-ft
13-in nominal hole, 0--18-ft
9-in nominal hole, ~18-78-ft
8-in ID carbon steel casing, +2.0--35-ft
(Pulled back from total depth)
Telescoping screen, 34-78-ft
Borehole drilled depth: [78.0-ft]

Drawing By: RKL/1-N-34.ASB
Date : 14Dec94
Reference : HANFORD WELLS

199-N-34

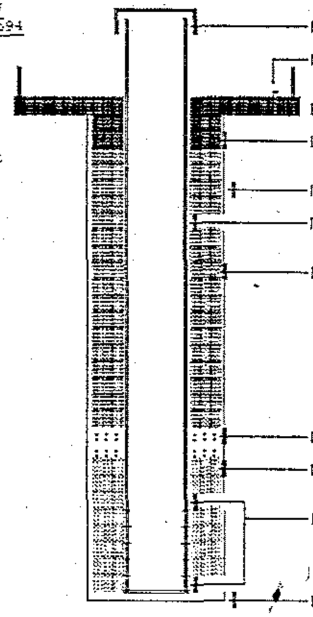
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool	WELL NUMBER: 199-N-56 A4699 TEMPORARY WELL NO: 1310-N #1
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford N-Area Coordinates: N/S N 6,998 N 86,066 E/W N 6,206 W 60,637
Driller's Name: O. Amos	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 149,703.49m N 491,212 E 571,375.87m E 2,234,467
Drilling Company: Associated Well Drill	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 11Jun87	Date Complete: 25Jun87	Elevation Ground surface: 454.3-ft Estimated

Depth to water: 61.0-ft Jun87
(Ground surface) 70.4-ft 13Sep94

GENERALIZED Geologist's
STRATIGRAPHY Log

0-46: Sandy GRAVEL
46-60: Silty sandy GRAVEL,
Ringold Contact @ 46-ft
60-70: Medium SAND
70-74: Gravelly SAND



Elevation of reference point: [458.09-ft]
(top of casing)
Height of reference point above [3.8-ft]
ground surface
Depth of surface seal [0-4.5-ft]
Type of surface seal,
4-ft by 4-ft concrete surface pad
extending 4.5-ft into annulus
11-in nominal hole, 0-74-ft
6-in ID stainless steel casing,
+3.8-59.0-ft
Granular bentonite, 4.5-47.5-ft
Bentonite pellets, 47.5-53.5-ft
10-20-mesh silica sand, 53.5-74.0-ft
6-in T304 stainless steel screen,
59.0-74.0-ft, #20-slot
Borehole drilled depth: [74.0-ft]

Drawing By: RKL/1-N-56.ASB
Date : 19Dec94
Reference : HANFORD WELLS

199-N-56

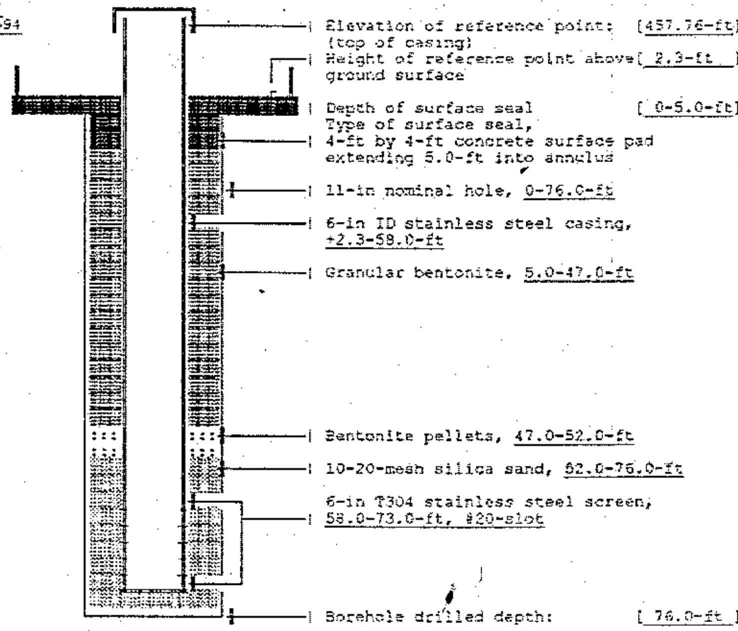
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool	WELL NUMBER: 199-N-57 A4700 TEMPORARY WELL NO: 1310-N #6
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford N-Area Coordinates: N/S N 6,569 N 85,535 E/W W 5,887 W 60,517
Driller's Name: L. Cordon	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 149,542.05m 490,682 E 571,413.17m 2,234,589
Drilling Company: Associated Well Drill	Company Location: Not documented	Start Card #: Not documented T____ R____ S______
Date Started: 12Jun87	Date Complete: 25Jun87	Elevation Ground surface: 455.5-ft Estimated

Depth to water: 60.0-ft Jun87
(Ground surface) 69.3-ft 13Sep94

GENERALIZED Geologist's
STRATIGRAPHY Log

0-60: Sandy GRAVEL
Ringold contact @ 57-ft
60-76: Gravelly silty SAND



Drawing By: RKL/1-N-57.ASE
Date : 19Dec94
Reference : HANFORD WELLS

199-N-57

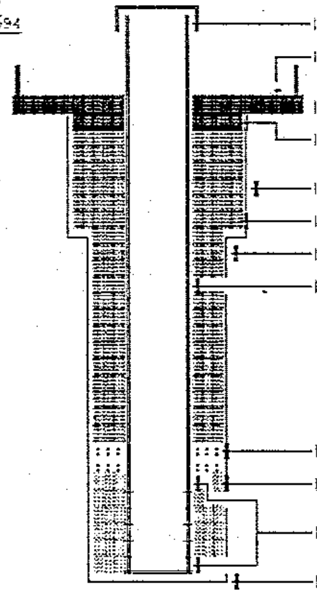
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Dart bailer	WELL NUMBER: 199-N-59 A4702 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford N-Area Coordinates: N/S N 5,176 N 61,029 E/W W 5,855 W 84,252
Driller's Name: O. Amos	WA State Lic Nr: 1224	State NAD83 Coordinates: N 149,150.45m N 489,397 E 571,258.23m E 2,234,090
Drilling Company: Kaiser Engineers	Company Location: Richland, WA	Start Card #: Not documented T___ R___ S___
Date Started: 21Sep87	Date Complete: 19Nov87	Elevation Ground surface: 457.58-ft Brass cap

Depth to water: 59.4-ft Sep87
(Ground surface) 71.0-ft 12Sep94

GENERALIZED Geologist's STRATIGRAPHY Log

0-20: Sity sandy GRAVEL
(Excavated by backhoe)
20-63: Sandy GRAVEL
63-65: Ringold Fm contact
65-70: Silty sandy GRAVEL
70-72.5: Silty SAND



Elevation of reference point: [459.53-ft]
(top of casing)

Height of reference point above [2.0-ft]
ground surface

Depth of surface seal [0-3.0-ft]

Type of surface seal,
4-ft by 4-ft concrete surface pad extending 3-ft into annulus

13-in nominal hole, 0-20.5-ft

Granular bentonite, 3.0-50.0-ft

11-in nominal hole, 20.5-72.5-ft

6-in ID stainless steel casing, +2.1-56.5-ft

Bentonite pellets, 50.0-56.5-ft

10-20-mesh silica sand, 56.5-72.5-ft

6-in T304 stainless steel screen, 56.5-71.5-ft, #20-slot

Borehole drilled depth: [72.5-ft]

Drawing By: RKL/1-N-59.ASB
Date : 19Dec94
Reference : HANFORD WELLS

199-N-59

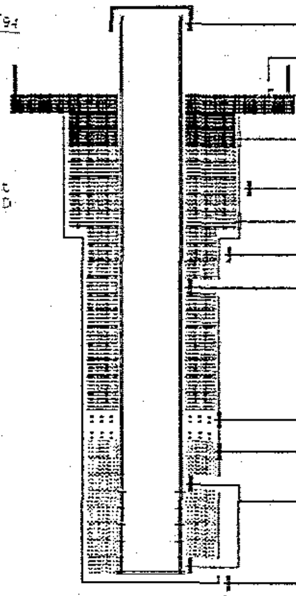
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool	WELL NUMBER: 199-N-64 A4708 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford N-Area Coordinates: N/S N 6,774 N 85,564 E/W W 5,451 W 60,030
Driller's Name: L. Watkins	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 149,551.18m 490,712 E 571,561.41m 2,235,076
Drilling Company: Kaiser Engineers	Company Location: Richland, WA	Start Card #: Not documented T___ R___ S___
Date Started: 15Oct87	Date Complete: 19Nov87	Elevation Ground surface: 452.2-ft Brass cap

Depth to water: 58.5-ft Oct87
(Ground surface) 65.4-ft 13Sep94

GENERALIZED Geologist's
STRATIGRAPHY Log

0-19: Not documented
(Excavated by backhoe)
20-49: Sandy GRAVEL
49-64: Silty sandy GRAVEL
Ringold contact at 63-ft
64-69.5: Slightly gravelly SAND



Drawing By: RKL/1-N-64.ASB
Date : 20Dec94
Reference : HANFORD WELLS

199-N-64

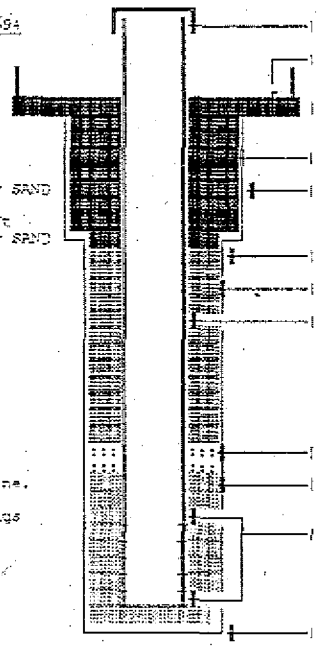
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool	WELL NUMBER: 199-N-67 A4711 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford N-Area Coordinates: N/S N 7,435 N 86,377 E/W W 5,970 W 60,248
Driller's Name: O. Amos	WA State Lic Nr: 1224	State NAD83 Coordinates: N 149,793.95m N 491,524 E 571,494.16m E 2,234,856
Drilling Company: Kaiser Engineers	Company Location: Richland, WA	Start Card #: Not documented T ___ R ___ S ___
Date Started: 16Feb88	Date Complete: 02Mar88	Elevation Ground surface: 456.80-ft Brass cap

Depth to water: 65.0-ft Feb88
(Ground surface) 72.5-ft 13Sep94

GENERALIZED Geologist's
STRATIGRAPHY Log

0-14: Sandy GRAVEL
14-19: Silty sandy GRAVEL
19-24: Gravelly silty SAND
24-39 Silty sandy GRAVEL
39-43: Slightly silty gravelly SAND
43-54: Silty sandy GRAVEL
Ringold contact at 43-ft
54-59: Slightly silty gravelly SAND
59-74: Silty sandy GRAVEL
74-79: Sandy GRAVEL



Elevation of reference point: (top of casing) [458.46]
Height of reference point above ground surface [1.7-ft]
Depth of surface seal [0-20-ft]
Type of surface seal,
4-ft by 4-ft concrete surface pad
Cement grout to 20-ft
13-in nominal hole, 0--19-ft
11-in nominal hole, -19-79-ft
Granular bentonite, 20.0-49.5-ft
6-in ID stainless steel casing, +1.7-60.5-ft
Bentonite pellets, 49.5-54.5-ft
10-20-mesh silica sand, 54.5-79.0-ft
6-in ID T304 stainless steel screen, 60.5-76.0-ft, #20-slot
Depth bottom of borehole: [79.0-ft]

DRILLING NOTE:
Well drilled in radiation zone. Contamination encountered while drilling. Field readings of 3-10,000 dpm 40-75-ft

Drawing By: RKL/1-N-67.ASB
Date : 21Dec94
Reference : HANFORD WELLS

199-N-57

0500264

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	199-N-71 A4714
Drilling Fluid Used:	NA	Additives Used:	None	TEMPORARY WELL NO	None
Driller's Name:	Joe Ockert	WA State Lic Nr:	Not Available	Coordinates: N	Not documented
Drilling Company:	KEH Const. Forces	Company Location:	Hanford	Coordinates: E	Not documented
Date Started:	07Aug91	Date Completed:	28Oct91	Start Card #:	Not Available
				Elevation Ground Surface:	

Depth to Water: 58.1 ft 28Oct91
(Ground surface)

GENERALIZED STRATIGRAPHY Geologist's Log

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 18 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 5 ft : Slightly Gravelly Silt

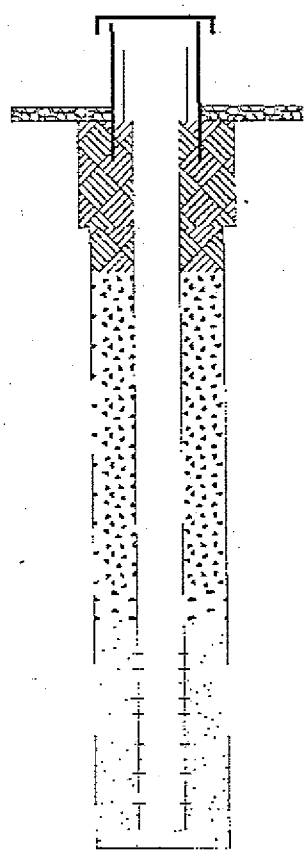
5 - 10 ft : Silty Sandy Gravel

10 - 25 ft : Gravelly Sandy Silt

25 - 45 ft : Gravel

45 - 85 ft : Sandy Gravel

85 - 87.05 ft : Sandy Gravel



Fill	Casing	Screen
0 - 12.61 ft : 13-inch hole Cement	0 - 12.61 ft : 13 inch 12-3/4" CS Temp. Welded Csg.	63.8 - 84.5 ft : 4 inch 4" .020 SS Wire Wrap Pipe Size
12.61 - 18 ft : 11-inch hole Cement	0 - 63.8 ft : 4 inch 4" Casing	
18 - 55.8 ft : 11-inch hole Bentonite Crumbles	12.61 - 87.05 ft : 11 inch 10-3/4" CS Temp. Welded Csg.	
55.8 - 59.7 ft : 11-inch hole Bentonite Pellets	84.5 - 84.8 ft : 4 inch	
59.7 - 84.8 ft : 11-inch hole 10-20 Silica Sand		
84.8 - 87.05 ft : 11-inch hole 10-20 Silica Sand		

87.05 ft : Borehole drilled depth

0 - 12.61 ft : 13-in. 12-3/4" Temp. Welded Csg. w/13" shoe
12.61 - 87.05 ft : 11-in. 10-3/4" Temp. Welded Csg. w/11" shoe

Drawing By: DLF
Reference: Hanford Wells
Revision: 0
Revision Date: 18Dec97
Print Date: 18Dec97

Report Form: WELLS Project File: WELLS.GPJ

BECHTEL

199-N-71

0503091

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	199-N-72 A4715
Drilling Fluid Used:	NA	Additives Used:	None	Coordinates N:	Not documented
Driller's Name:	J. Ockert	WA State Lic Nr:	Not Available	Coordinates E:	Not documented
Drilling Company:	KEH Constr. Forces	Company Location:	Hanford	Start Card #:	Not Available
Date Started:	30Aug91	Date Completed:	30Oct91	Elevation Ground Surface:	

TEMPORARY WELL NO: None

Depth to Water: 65.1 ft 25Oct91
(Ground surface)

Elevation of Reference Point: m

Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 20.5 ft.

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY — Geologist's Log

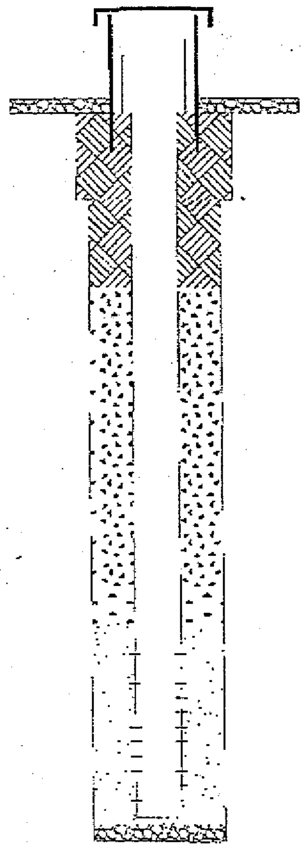
0 - 35 ft : Sandy Gravel

35 - 55 ft : Gravel

55 - 65 ft : Sandy Gravel

65 - 80 ft : Gravel

80 - 85.01 ft : Sandy Gravel



Fill	Casing	Screen
0 - 10.09 ft : 13-inch hole Cement	0 - 10.09 ft : 13 inch 12-3/4" CS Temp. Casing	
10.09 - 20.5 ft : 11-inch hole Cement	0 - 61.22 ft : 4 inch 4" Perm. Casing	
20.5 - 55.5 ft : 11-inch hole Bentonite Crumbles	10.09 - 85.01 ft : 11 inch 10-3/4" CS Temp. Casing	
55.5 - 59.3 ft : 11-inch hole Bentonite Pellets		61.22 - 82 ft : 4 inch 4" .020 SS Wire Wrap Pipe Size
59.3 - 82.25 ft : 11-inch hole 10-20 Silica Sand		
82.25 - 83 ft : 11-inch hole 10-20 Silica Sand	82 - 82.25 ft : 4 inch End Cap	
83 - 85.01 ft : 11-inch hole Slough		

85.01 ft : Borehole drilled depth

0 - 10.09 ft : 13-in. 12-3/4" CS Temp. Casing
10.09 - 85.01 ft : 11-in. 10-3/4" CS Temp. Casing

Drawing By: DLF
Reference: Hanford Wells
Revision: 0
Revision Date: 27Jan98
Print Date: 27Jan98

Report Form: WELLS Project File: WELLS.GPJ

BECHTEL

199-N-72

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	199-N-73 A4718	TEMPORARY WELL NO:	None
Drilling Fluid Used:	NA	Additives Used:	None	Coordinates: N	Not documented		
Driller's Name:	D. Kruger	WA State Lic Nr:	Not Available	Coordinates: E	Not documented		
Drilling Company:	KEH Constr. Forces	Company Location:	Hanford	Start Card #:	Not Available		
Date Started:	26Aug91	Date Completed:	16Sep91	Elevation Ground Surface:			

Depth to Water: 68.3 ft 16Sep91
(Ground surface) 69.3 ft 30Oct91

GENERALIZED STRATIGRAPHY Geologist's Log

Elevation of Reference Point: ft

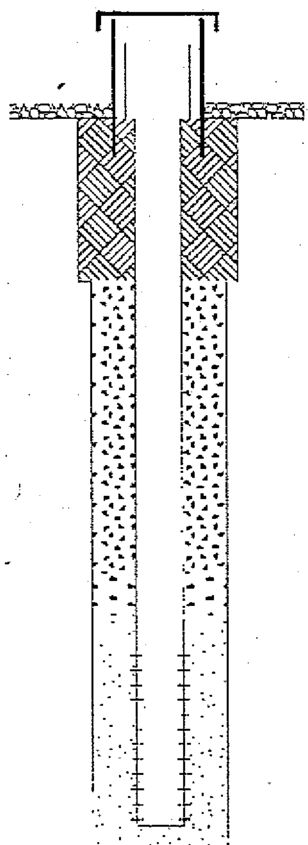
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 19.7 ft.

Type of Surface Seal: 4x4 Concrete Pad

0 - 55 ft : Gravel

55 - 89.1 ft : Sandy Gravel



Fill	Casing	Screen
0 - 19.7 ft : 13-inch hole Cement	0 - 19.92 ft : 13 inch 12-3/4" CS Temp. Welded Csg. 0 - 65.6 ft : 4 inch 4" Casing	
19.7 - 19.92 ft : 13-inch hole Bentonite Crumbles	19.92 - 89.3 ft : 11 inch 10-3/4" CS Temp. Welded Csg.	
19.92 - 55.5 ft : 11-inch hole Bentonite Crumbles		
55.5 - 60.6 ft : 11-inch hole 3/8" Bentonite Pellets		65.6 - 86.1 ft : 4 inch 4" .020 SS Wire Wrap Pipe Size
60.6 - 86.4 ft : 11-inch hole 10-20 Silica Sand		
86.4 - 89.3 ft : 11-inch hole 10-20 Silica Sand	86.1 - 86.4 ft : 4 inch	

89.1 ft : Borehole drilled depth

0 - 19.92 ft : 13-in, 12-3/4" Carbon Steel Temp. Casing
19.92 - 89.1 ft : 11-in. 10-3/4" Carbon Steel Temp. Casing

Drawing By: DLF
Reference: Hanford Wells
Revision: 0
Revision Date: 19Dec97
Print Date: 19Dec97

Report Form WELLS Project File WELLS.GPJ

BECHTEL

199-N-73

0500149

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Air Rotary	Sample Method:	Grab/Split Spoon	WELL NUMBER:	199-N-77 A5442	TEMPORARY WELL NO:	None
Drilling Fluid Used:	NA	Additives Used:	None	Coordinates: N	Not documented		
Driller's Name:	D. Mingo	WA State Lic Nr:	Not Available	Coordinates: E	Not documented		
Drilling Company:	Jensen Drilling	Company Location:	Richland, WA	Start Card #:	Not Available		
Date Started:	30Jul92	Date Completed:	14Oct93	Elevation Ground Surface:			

Depth to Water: 80.45 ft 24Sep93
(Ground surface)

Elevation of Reference Point: m

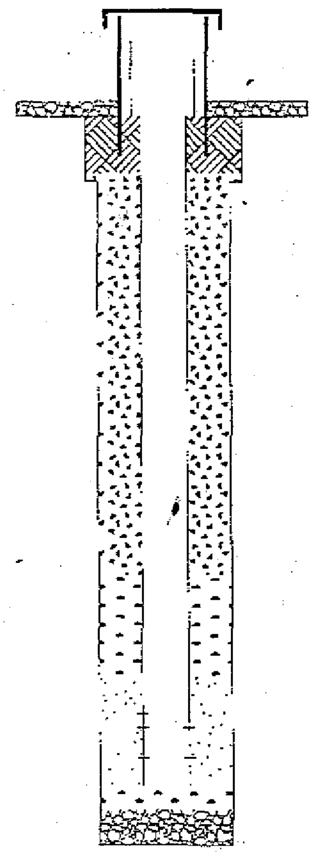
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: 8.0 ft.

Type of Surface Seal: 4x4 Concrete Pad

GENERALIZED STRATIGRAPHY Geologist's Log

0 - 5 ft : Gravel
5 - 13 ft : Sandy Gravel
13 - 20 ft : Gravel
20 - 29 ft : Sandy Gravel
29 - 38 ft : Sandy Gravel
38 - 42 ft : Gravel
42 - 45 ft : Sandy Gravel
45 - 48 ft : Gravel
48 - 49 ft : Sand
49 - 52 ft : Sandy Gravel
52 - 55 ft : Sand
55 - 56 ft : Gravel
56 - 57 ft : Sand
57 - 88 ft : Gravel
88 - 97 ft : Sandy Gravel
97 - 100 ft : Silt and Clay
100 - 102 ft : Silty Sand
102 - 103 ft : Silty Clay



103 ft : Borehole drilled depth

0 - 9.2 ft : 13-in. 12-3/4" Carbon Steel Temp. Casing
9.2 - 103 ft : 11-in. 10-3/4" Carbon Steel Temp. Casing

Fill

0 - 8 ft : 13-inch hole Cement
8 - 9.2 ft : 13-inch hole Bentonite Crumbles
9.2 - 64.7 ft : 11-inch hole Bentonite Crumbles
64.7 - 79.4 ft : 11-inch hole Bentonite Tablets
79.4 - 94.6 ft : 11-inch hole 20-40 Silica Sand
94.6 - 94.9 ft : 11-inch hole 20-40 Silica Sand
94.9 - 98.1 ft : 11-inch hole Bentonite Tablets
98.1 - 103 ft : 11-inch hole Slough

Casing

0 - 9.2 ft : 13 inch 12-3/4" CS Temp. Welded Csg.
0 - 84.36 ft : 4 inch 4" Perm. Casing
9.2 - 103 ft : 11 inch 10-3/4" CS Temp. Welded Csg.
94.3 - 94.6 ft : 4 inch 4" PVC Cap

Screen

84.36 - 94.3 ft : 4 inch 4" .010 SS Wire Wrap Pipe Size

Drawing By: DLF
Reference: Hanford Wells
Revision: 0
Revision Date: 19Dec97
Print Date: 19Dec97

Report Form: WELLS Project File: WELLS.GPJ

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